Feasibility Study For a Biotechnical Shoreline Stabilization Project

For The

Lake Lemon Conservancy District
Unionville, IN

and the

Indiana Department of Natural Resources,
Division of Soil Conservation
Lake and River Enhancement Program

By

Commonwealth Biomonitoring, Inc.

February, 1997

Lake Lemon Shoreline Stabilization Brief Feasibility Study

Introduction

Lake Lemon is the eleventh largest lake or reservoir in Indiana at 1,650 original surface acres. It is located primarily in northeast Monroe County and partially in northwest Brown County (see Location Map in Exhibit 2). Lake Lemon was impounded in 1954 to be used as a surface water supply reservoir for the City of Bloomington. The original maximum depth was 30 feet near the dam. It was designed to supplement the Griffy Reservoir water supply.

Monroe Reservoir was constructed in 1964 and in the 1970's the City of Bloomington Utilities (CBU) began to withdraw drinking water from Lake Monroe. After the Monroe Reservoir plant was fully on-line Lake Lemon was no longer used for drinking water supply by the CBU. However, there are still several private homes (particularly on the north shore of Lake Lemon) that continue to utilize Lake Lemon water for potable uses.

Most southern Indiana reservoirs are constructed on soils that did not form as shoreline or wetland soils. Rather they were formed as forested dry mesic uplands soils. Thus, when exposed to water and wave energy they are typically highly erodible. At Lake Lemon this is the case. Much of the shoreline erosion appears to have stabilized somewhat. In many areas of Lake Lemon the upper soil layers have been eroded away exposing hard pan clay (fragipan) soil layers. Some shoreline areas around the lake also have active sloughing due to instability not entirely attributed to wave action.

Treating areas above the wave energy zone is beyond the scope of this project, yet, there are still several areas around the lake where the upland banks are actively sloughing due to undermining by wave action. These areas (primarily on City of Bloomington land) where there are translational slides or rotational slumps in the upland banks, while outside the scope of this project, should be treated at the same time that the wave energy zone is treated for economies of scale. However, the design contract will have to be amended to include geotechnical analysis, surveying, and engineering design for the upland bank failures.

The Lake Lemon Conservancy District has authorized a two (2) phase biotechnical shoreline stabilization project to address critical areas of shoreline erosion. Phase 1 is the preparation of a brief preliminary engineering study to categorize the subject shoreline by relative severity of erosion. Then, determine the most feasible shoreline treatment alternatives for various shoreline categories. Phase 2 will be a project to design the treatments recommended in Phase 1. Since the amount of construction funding is limited for shoreline stabilization, only the most severe shoreline sites will have designs and contract documents developed for them.

The subject shoreline that is the focus of the design project is approximately that area depicted as Category 1 Wave Energy Zone, Identified Critical Erosion in the attached Exhibit 1. The focus of this project is to protect the immediate shoreline of this area from wave energy erosion generated from wind and boat traffic on Lake Lemon. The stabilization of banks from upland soil stresses and soil mechanics conditions above the wave energy zone is beyond the scope of this project.

above still water level. This assumes a 20' deep draft pleasure boat operated at 20 MPH.

CBI staff also consulted Dave Ison, owner of I&S Marina on the size and type of boats moored on Lake Lemon and the magnitude of waves generated from the larger boats. Mr. Ison concurred that the estimated maximum boat generated wave heights on Lake Lemon would be three (3) feet, based on his experience and knowledge of the boats presently and historically moored and launched on Lake Lemon.

Therefore, most of the main body lake shore is subjected to frequent sustained boat generated wave action of three feet high or less. Exhibit 1 depicts this shoreline area as Category 1.

B. Wave Runup

Wave runup is dependent on the slope and surface roughness of each individual site. The steeper a lake shore is the higher waves will run up the bank. Also, the smoother the lake shore soil or cover, the higher the wave runup. Wave runup can be reduced in two ways, by reducing the lake shore slope and by increasing the surface roughness of the slope. Rip rap and contained coarse stone is a very effective method to increase the surface roughness of a lake shore. Excavation to reduce soil slopes is relatively expensive.

Wave runup will be calculated after obtaining lake shore slope information from a topographic survey. After completion of a topographic survey, wave runup can be calculated for each identified critical area.

C. Measured Wave Energy Zones

At two critically eroding shoreline areas, one at the farthest eastern fetch and the other at the farthest western fetch distance of Lake Lemon (see Exhibit 1), the high energy zone shoreline erosion evidence was measured from the water level (at normal pool) to the top of the high wave energy zone. In both cases, the shoreline eroded from direct wave energy was limited to no higher than 3' above the normal pool water level. Of course slopes higher than 3' are failing around Lake Lemon, however, the higher elevation erosion was due to erosion of the toe of the slope.

D. Lake Levels

1. Sustained Maximum Lake Level Elevation

The IDNR Division of Soil Conservation provided U.S.G.S. lake level data from 1961 through 1965 and 1967. The U.S.G.S. data is relatively old data but the "best available information." Because Lake Lemon was a water supply reservoir throughout the data period (1961 through 1965 and 1967) the lake level was commonly drawn down for water supply during dry periods. Now that the lake is no longer used as a water supply reservoir the water level is not substantially reduced during dry periods. Therefore, the low water level elevations from the 1961 - '65 and 1967 data set are no

Table 1
High Water Elevation Data From U.S.G.S. 1961 - 1965 and 1967 Data Set

Year of Record	Peak Gage Height	Peak Lake Elevation	Avg. of 3 Highest Gage Heights in Year of Record	Avg. of 3 Highest Lake Elevations in Year of Record
1961	10.2'	630.3'	10.2'+10.13'+10.02'/3= 10.12'	630.22'
1962	11.0'	631.1'	11.0'+11.0'+10.88'/3 = 10.96'	631.06'
1963	11.72'	631.82'	11.72'+10.92'+ 10.81'/3 = 11.15'	631.15'
1964	11.06'	631.16'	11.06'+10.67'+10.67'/3 = 10.8'	630.9'
1965	10.85'	630.95'	10.85'+10.78'+10.73'/3 = 10.79'	630.89'
1967	11.70'	631.8'	11.70'+11.40'+11.18'/3 = 11.42'	631.52'
Average of 6 years	11.1'	631.2'	10.87'	630.97'

II. CATEGORIZATION OF SHORELINE AREAS BY WAVE ENERGY ZONES

A. Wave Energy Zones

The range of lake levels, described in Table 2 of the previous section, combined with the wind and boat generated wave estimates (estimated using USDA, NRCS methods) were used to categorize the various lake shore areas by their potential shoreline erosion effects.

Maximum wave heights are evaluated based on fetch (length of unimpeded wind travel across water), prevailing wind direction, and powerboat induced wave heights within the project area. From this analysis wave energy zones have been established. These are:

Category 1 Wave Energy Zone	-	Sustained waves heights greater than 2 ft.
Category 2 Wave Energy Zone	-	Sustained waves heights 2 feet or less.
Category 3 Wave Energy Zone	-	Sustained waves heights 1 foot or less.

Category 1 wave energy shorelines are further broken down by the nature and severity of the erosion on the banks. There are several Category 1 areas that have more severe active erosion than other Category 1 sites. The areas with the greatest erosion severity have the following general characteristics:

- The shore slopes are steeper;
- There is less woody vegetation, the ground cover has been converted from forested to lawn or grass;
- They have the longest fetch distances for wind generated wave action.

B. Shoreline Erosion Evaluation

Aerial photographs were obtained by CBI for comparative shoreline erosion analysis from two sources: The Monroe County office of the USDA Farm Services Agency and the Monroe County Surveyor's office. The original intent of obtaining the aerial photographs was to compare older shoreline locations to more recent shoreline locations to measure the rate of shoreline receedance.

After close scrutiny the aerial photographs are of very limited value in making comparisons across years on shoreline locations. The obtainable aerial photos were of poor quality and the lake levels were slightly inconsistent for precise comparison.

Because the aerial photos provided little information on erosion patterns, field assessments were made of the shoreline areas. Sites for treatment were field inspected, measured and photographed. The Category 1 areas of highest potential erosion are depicted on Exhibit 1.

falling should be removed. If the bank the tree is on does not require reshaping, the trees should be cut off above the base to leave the stump and root system intact to hold bank soils. Any trees that must be removed for shoreline reshaping should be placed along the shoreline for fish habitat and additional wave energy reduction.

In most cases, trees that present a wind throw hazard are removed in the course of construction. There is an economy of scale to address potential wind throws during the construction process rather than as a maintenance measure in the future. However, the some of the specific trees on the Lake Lemon shoreline that presently present a wind throw hazard are also used frequently as perching sites for the resident and migratory bald eagles at Lake Lemon. Thus, it is not prudent to design or specify for removal of any more than the minimum amount of shoreline trees necessary to access sites and install measures.

Conceptual plans for the lake shore stabilization are included as Exhibits in Appendix A of this report. Appendix B contains cost estimation worksheet attachments per linear foot of treatment. Following are descriptions of the alternative treatment measures deemed most feasible for treatment of the Lake Lemon shoreline areas.

A. Assumptions on Construction Conditions

The following conditions were assumed for each treatment alternative to make comparisons based on the merits of each treatment and make the comparisons more independent of individual lake shore conditions. The Feasibility cost estimation worksheets included in Appendix B have the following and peripheral/non construction costs included:

- Treat an average of 4.5 (vary from 3' - 6') feet wide wave energy zone on the lake shore.
- No stabilization of upland bank failure.
- Area to be treated per linear foot of shoreline .5 square yards (or 4.5 sq. ft.).
- Assume similar access road construction costs for each treatment method.
- Small, light, mobile equipment will be used for shoreline work.
- Bare bank areas above the wave energy zone are outside the scope of this project.
- Minimal excavation work performed.

Included in the prices for each treatment alternative are the following additional costs as a percent of the unit (linear feet) cost of installed treatment alternative:

- Mobilization/Demobilization - 10%
- Contingencies - 10%
- Bonding - 10%
- Prevailing Wages - 25%
- Non-construction costs (easements, inspection) - 20% (Note: Access road improvements are not included in the mobilization cost estimates)

Advantages

When installed properly tri-lock blocks are attractive and long lasting. At a shoreline stabilization demonstration site at Paynetown Recreation Area at Lake Monroe, Tri-Lock blocks were the most protective and longest lasting measure installed in a very high energy wave environment.

Disadvantages

The preparation of slope sub grade, geofabric, installation of pre-cast interlocking concrete blocks, and subsequent backfill is a labor intensive alternative for shoreline protection. Pre cast interlocking blocks are difficult to use in conjunction with vegetative re-establishment for shoreline stabilization. In addition, the existing banks would have to be cleared to accommodate the blocks.

b. Unconfined Stone Rip Rap

Conceptual Design

Treatment of Category 1 wave energy zones with this method involves minimal site prep, placing dumped and machinery spread rip rap (with limited hand placement) on an 8 ounce geofabric and no slope reduction excavation. This does include digging a key trench and filling the key trench with stone. In addition, the unit cost includes adding a smaller grade of stone to the rip rap to embed the rip rap voids. Above the wave energy zone (in the saturated spray area) a coconut fiber erosion control blanket can be installed with plantings beneath the blanket.

Exhibit 4 of Appendix A depicts a conceptual drawing of this alternative.

Estimated Costs

This is a cost effective alternative for Category 1 wave energy zones. To treat Category 1 wave energy zones with this method Attachment 1 in Appendix B estimates the unit cost to be $100/L.F.

Attachment 5 in Appendix B provides a breakdown of the costs for each linear foot of treated shoreline using rip rap for Category 2 wave energy zones at approximately $67/L.F.

Advantages

One of the primary advantages of rip rap that makes it a versatile and cost effective treatment is the minimal site prep that is necessary prior to placing the stone. The stone can be placed around existing obstructions such as driftwood; wind throws; and old, existing, failed shoreline revetment.

biotechnical treatment for Category 2 from Exhibit 5 is estimated to cost $93 by the Attachment 4 worksheet including installed soft measures.

Advantages

Confined stone has four primary advantages over unconfined rip rap:

- It can be placed on a steeper slope (1H:1V) (mattresses and baskets).
- It takes less stone (where moving stone is a problem) to fill mattresses and rock rolls, because the stone layers can be thinner.
- Smaller sizes of stone can be used which are easier to handle.
- Gabion baskets make an excellent breakwater in front of failing slopes in applications where it is not in the economic best interest of the LLCD to treat the entire slope.

Stone from 1.5" to 5" can be used in contained mattresses (depending on the mesh size) as opposed to rip rap which would require a minimum size of 8" to 10" in most Lake Lemon applications.

Disadvantages

The major disadvantages of stone mattresses are:

- They cannot be placed on a bank with existing logs, drift, trees, and other debris and obstructions without first removing those obstructions.
- The mattresses are another material to handle making for a slightly more complex project, and corresponding cost.
- Stacked gabion baskets as a retaining wall generally require backfilling behind the constructed retaining wall.
- Mattresses must be anchored to the slopes, past the slip plane in a failing or potentially failing slope. Anchoring can be labor intensive if the anchors have to be driven more than a few feet into the bank to reach solid earth beyond a slip plane.

Galvanized Wire Vs. Synthetic Geogrid Mattresses

Positive Attributes of Synthetic Geogrids

Smaller #2 stone can be used in a geosynthetic mattress given the smaller mesh opening sizes compared to #1 stone in a wire mattress. Smaller stone is easier to handle thus reducing costs.

Disadvantages of Synthetic Geogrid Mattresses

Given the nature of the synthetic geogrid being a plastic compound, the material is less UV stable than galvanized wire mattresses. Synthetic geogrids also have a slightly lower tensile strength than wire mattresses. Stretching of the mattress could occur, especially in warmer temperatures which may result in sagging of the mattress with settling of

water. This particular conceptual application in Exhibit 6 includes a plant pallet application.

Exhibit 5 in Appendix A presents a concept utilizing a biolog in conjunction with a rock roll for Category 2 wave energy zone applications.

Estimated Costs

The estimated cost for the Exhibit 6 concept is presented in Attachment 6 in Appendix B. The estimated cost per linear foot for this application is approximately $70/L.F.

The estimated cost for the Exhibit 5 concept is presented in Attachment 4 in Appendix B. The estimated cost per linear foot for this application is approximately $93/L.F.

Another cost estimate spreadsheet was developed for a concept that only includes a planted biolog with planted plugs in the soil behind the biolog. Similar to the Exhibit 5 concept but without the plant pallet coconut fiber blanket. This cost estimate is presented in Attachment 7 in Appendix B. The estimated cost per linear foot for this application is approximately $55/L.F.

Advantages

The major advantages for the biolog is that it can be installed rapidly along a convoluted shoreline and around shoreline obstructions. In addition, plant plugs can be placed directly into the biolog for a stable substrate for plants to root in. The biolog can also create a relatively still environment in shallow water behind the biolog to promote the establishment (either naturally or planted) of aquatic vegetation to further stabilize the shoreline.

Disadvantages

While soft treatments are widely used, the major disadvantage to "soft " shoreline treatments is that the manufacturers generally have not published technical data regarding the ability of the products to withstand shear stresses in wave energy environments, and the longevity of the treatments in various wave energy conditions.

There simply are no specific design guidelines and parameters for the practice of engineering soft shoreline stabilization measures backed up by data from long-term performance studies. Design engineers are understandably apprehensive in designing and specifying soft measures even where they are substantially less expensive.

erosion control retailers. The concepts are presented in Exhibits 7 and 8 in Appendix A.

Estimated Costs

The estimated unit cost of installed and planted coconut erosion control blankets is estimated to be approximately $12/L.F.

Advantages

The coconut blankets are very durable in high velocity applications such as channels. They are very easy to install, and plants can readily be planted through the blankets. They have a well established performance record with shear stresses such as water moving across it.

Disadvantages

The blankets must lay flat on the soils to be optimally effective. The surface beneath the blanket must be relatively free of obstructions with the blanket lying flat on substrate. There is not good research data readily available to document the performance of the coconut erosion control blankets in a lake shore environment, where there is a near continuous vacuum action from receding waves.

3. Longshore Current Protection With Existing Lake Shore Materials

Because Lake Lemon is oriented in east to west, prevailing west to southwest winds are near parallel to much of the critically eroding shoreline (especially on the north shore). In longshore applications, groins (projections perpendicular to the shoreline) can be used to stabilize longshore transport of beach or shoreline sediments. Several property owners on the north shore have noticed the migration of sand and small pea gravel they have dumped for beaches.

From observation, in inland reservoirs in central Indiana naturally occurring deadfalls (trees that have fallen into the lakes) provide a longshore current break. Trees that are laying on the shoreline generally have a higher substrate elevation on the leeward side of the tree (or other obstruction) than on the windward side. In addition, especially in older reservoirs where the original woody cover has deteriorated, trees laying on the shoreline provide significant game fish habitat.

Obtaining harvestable trees to be used as "groins" or for the creation of fish habitat at reservoirs is generally a problem. Shoreline trees, unless they pose a windfall risk, have a soil stabilizing root matrix that should not be disturbed. In certain cases an extremely steep slope that must be restored to a less steep (e.g., from 1H:1V reshaped to 2H:1V) slope may have some trees at the top of the bank that must be sacrificed. In these instances the trees should be utilized as a groin/fish habitat structure.

- tie up nutrients in macrophytes rather than algae, improving water clarity;
- buffer wave energy impacting the shoreline;
- filter the water column of suspended particles, improving water clarity;
- reduce herbicide treatment costs.

Lanes could be maintained through the vegetation to facilitate boat traffic to and from private docks.

IV. RECOMMENDED PLAN OF ACTION

Commonwealth Biomonitoring, Inc. recommends that the project move into the design phase to treat the most critical areas listed as extreme or severe in the Relative Severity of Erosion column of Table 3. All of the sites listed in Table 3 are in the Category 1 wave energy zones. The specific designed measures for each site will depend on the results of the topographic survey and geotechnical analyses.

A. Category 1 Shoreline Treatment Areas

From field measurements and inspections the Lake Lemon shoreline has been broken down into three major stabilization areas. Area 1 has the longest west to east fetch lengths in conjunction with steep slopes that have severe to extreme cases of Category 1 shoreline wave energy erosion. Area 2 is also located in the Category 1 wave energy zone, however, the sites are all located relatively near one another on the south shore of Lake Lemon. Area 3, again, is composed of sites in the Category 1 wave energy zones. Area 3 sites are all located on the north shore of Lake Lemon. The north shore is subject to near constant wave action and freeze/thaw erosion in winter. Other sites around Lake Lemon also need shoreline treatment, however, the sites listed in Table 3 are the Category 1 energy zone sites with the greatest protective needs.

Table 3 presents:
- A description of the individual identified sites within each general project area in need of treatment,
- the ownership of each site,
- the measured length of shoreline that needs to be treated at each site,
- relative severity of erosion for each site,
- the relative ease of access,
- the recommended alternative from the Exhibits in Appendix A with the estimated treatment costs from the Attachments in Appendix B.

1. Identified Upland Bank Failures

There are four identified and one potential (point between dam and spillway) active upland bank failures identified in the field inspections for this feasibility study. These are marked with an asterisk an Table 3 below. Since this project is focused on wave energy erosion at the toe of slopes rather than entire slope stability, Table 3 prescribes these sites be treated with a gabion basket/mattress breakwater structure in front of the

Table 3

Lake Lemon Measured Shoreline Areas, Severity, Ownership, and Access

Long East/West Fetch Sites Area 1	Ownership Public/Private	Linear Feet Of Treatment Needed	Relative Severity of Site Erosion	Relative Ease of Access	Treatment Alternative and Estimated Cost
Area 1a. - West side of Reid Point.	Private and CBU	444'	Extreme - upland sloughing*	Good - road needs improvement	Gabion Basket Breakwater Est.$75,500*
Area 1b. East end of lake n. of spillway.	CBU - Public	150' and 320'	Extreme - upland sloughing* (150')	Good - some improvement needed	Gabion Basket Breakwater Est. $25,500 and Exhibit 4, Est. $32,000*
Area 1c. pt. between dam and spillway.	CBU - Public	540'	Severe - not field checked - may be upland sloughing*	Good - some improvement needed	Exhibit 3 or 4, Est. $54,000*
Area 1d. Island	CBU - Public	200' (more less severe erosion)	Severe	Poor - boat only hand placed revetment**	Exhibit 4, Est $20,000**
Area 1e. Bank s. of dam.	CBU - Public	900'	Severe	Poor - boat mostly hand placed revetment**	Exhibit 4 Est $90,000**
Area 1f. North side of cove adjacent to spillway.	Private (?)	95'	Moderate	Fair access - needs some imp. from Spillway Road.	Exhibit 4 Est $9,500
South Shore Category 1 Sites Area 2	**Ownership Public/Private**	**Linear Feet Of Treatment Needed**	**Relative Severity of Site Erosion**	**Relative Ease of Access**	**Treatment Alternative and Estimated Cost**
Area 2a. Riddle Point Beach	CBU - Public	265'	Extreme - upland sloughing*	Excellent	Gabion Basket Breakwater Est. $45,050*
Area 2b. Riddle Pt. former campground	CBU - Public	445'	Severe	Excellent	Exhibit 4 Est.$44,500
Area 2c. Boys/Girls Club	~~Optimist - Private~~ CBU-Public	235'	Extreme - upland sloughing*	Excellent	Gabion Basket Breakwater Est. $40,000*
Area 2d. Peninsula near South Shore Dr.	Private	150'	Moderate	Excellent	Exhibit 4, Attachment 5 Est.$11,250
North Shore Category 1 Sites Area 3	**Ownership Public/Private**	**Linear Feet Of Treatment Needed**	**Relative Severity of Site Erosion**	**Relative Ease of Access**	**Treatment Alternative and Estimated Cost**
Area 3a. From Teeter Property East	CBU - Public	950'	Moderate	Fair - access roads at both ends of area. Lower lake for access.	Exhibit 5 Est. $90,250
Area 3b. "Eagle Point" LLCD property	CBU/LLCD Public	270'	Severe	Good - New LLCD Road	Exhibit 4 Est. $27,000
Area 3c. Immediately E. of Eagle Pt.	CBU - Public	240'	Moderate (Rock Roll/Biolog)	Fair - Extend New LLCD Road	Exhibit 5 Est. $22,800
Area 3d. E. end of Wildwood Rd.	CBU - Public	1,020'	Moderate (Rock Roll/Biolog)	Poor **- By boat or Road in back of cove.	Exhibit 5 Est. $96,900**
Area 3e. W. Dettemer Rd.	CBU - Public	720'	Moderate (Rock Roll/Biolog)	Poor **- By boat or Road in back of cove.	Exhibit 5 Est. $68,400**
Area 3f. Between Prible's (9418) and Barefoot Ave.	CBU - Public	125'	Severe	Poor **- By boat or Road in back of cove.	Exhibit 3 or 4 Est. $12,500**
Area 3g. E.. end of Dettemer Rd.	CBU - Public and Private	460'	Severe	Good Access from Dettemer Rd.	Exhibit 3 or 4 Est. $46,000
Area 3h.Small pt. adjacent to canal.	Unknown	160'	Moderate Attachment 5	Good access - Gray Ave., needs some imp.	Ex. 5 Est. $10,200
	Total Linear Ft. of Identified	7,689 L.F. Total	914' Extreme 3,440' Severe 3,335' Moderate	Total Est. Costs = $798,550	Extreme = $186,050 Severe = $326,000 Moderate=$286,500

* = Additional geotechnical evaluation and engineering design required to stabilize active bank failures.

** = Poor access may require hand placement of revetment at additional cost.

presented are for project planning purposes only and generated consistent with construction planning practices. The estimated costs per unit of treatment are in no way warranted.

VI. References

1. Slope Protection for Dams and Lake Shores, Technical Release 2, Minnesota NRCS, 1988.

2. Proceedings, U.S. Army Corps of Engineers, Water Operations Technical Support Program, Workshop on Reservoir Shoreline Erosion: A National Problem, October 26 - 30, 1992.

3. Reservoir Shoreline Revegetation Guidelines, U.S. Army Corps of Engineers, Hollis H. Allen and Charles V. Klimas, Environmental and Water Quality Operational Studies Technical, November 1986 Final Report.

4. Indiana NRCS Field Office Technical Guide, Chapter 7.

5. NRCS Engineering Field Handbook, Chapter 16.

6. Wildlife Resources Notes, Biotechnical Reservoir Shoreline Stabilization, U.S. Army COE., Volume 8 No. 1, March, 1990.

7. Wildlife Resources Notes, Biotechnical Shoreline Stabilization: Update Report, U.S. Army COE., Volume 9 No. 1, November, 1991.

Appendix A

Conceptual Designs of Shoreline Stabilization Alternatives

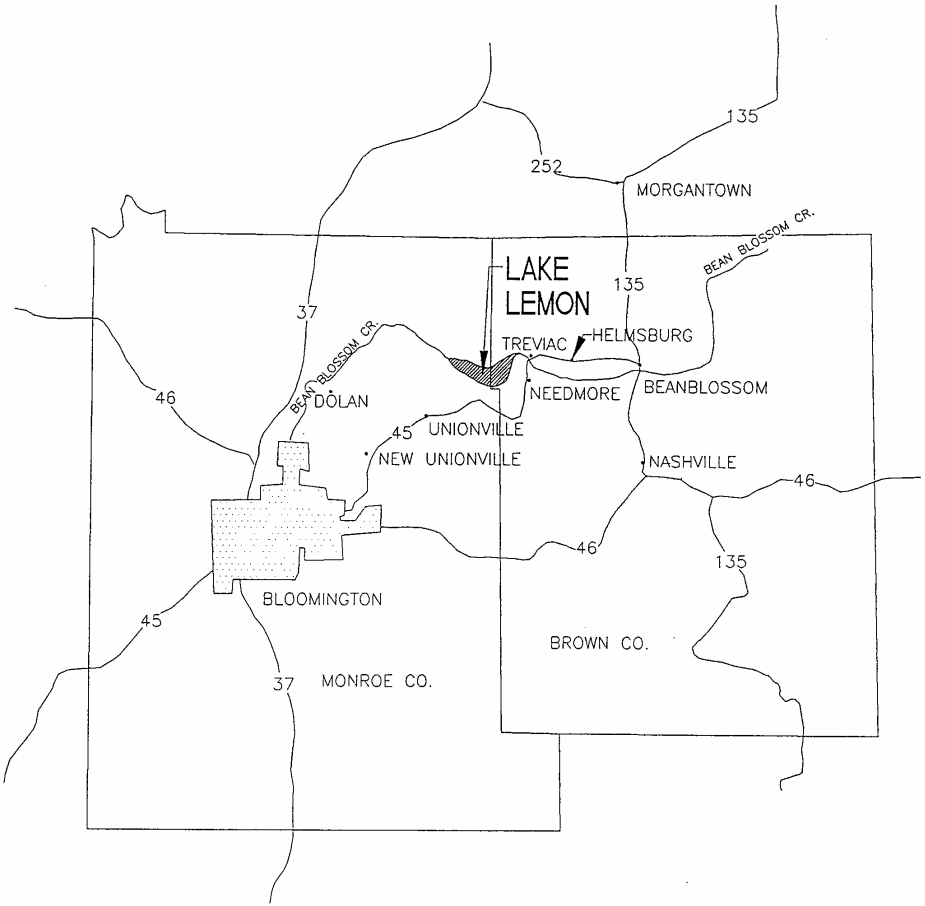
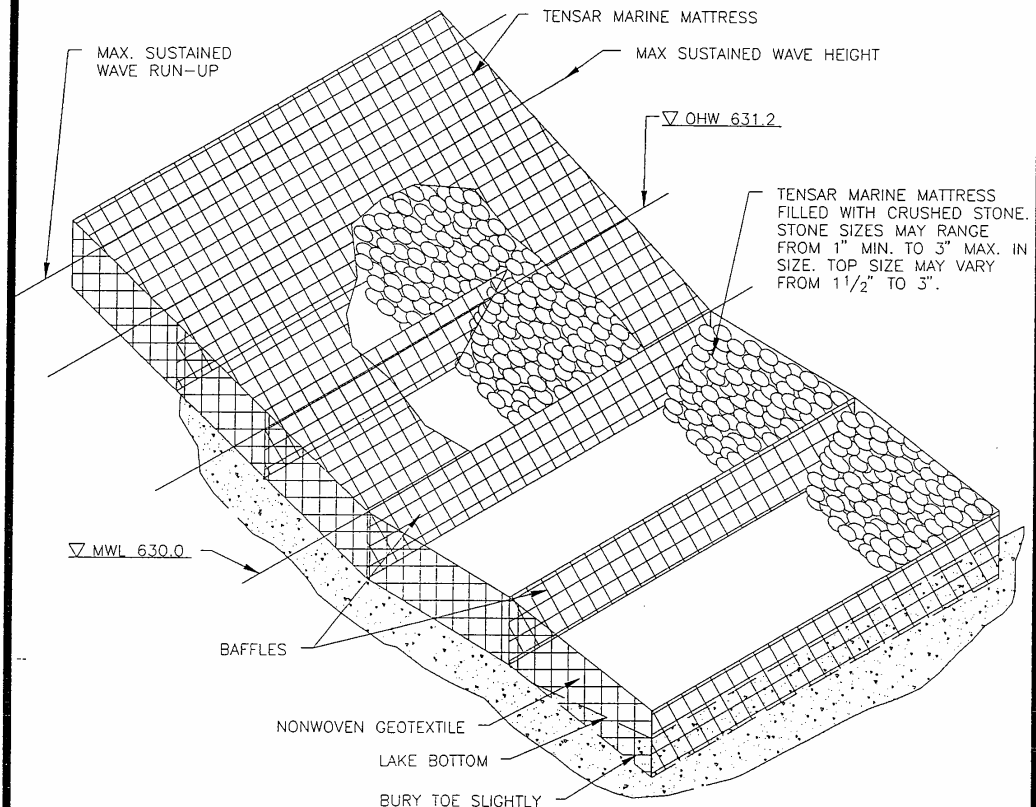


Exhibit 2

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILTY STUDY REPORT
LOCATION MAP

CATEGORY 1 WAVE ENERGY ZONE
CONTAINED FLEXIBLE REVETMENT FOR SLOPES > 2:1



NOT TO SCALE

Exhibit 3

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE 1 / SLOPE > 2:1
TYPICAL TENSAR MARINE MATTRESS

CATEGORY 1 WAVE ENERGY ZONE MAXIMUM SUSTAINED WAVE HEIGHT 3'
UNCONTAINED FLEXIBLE REVETMENT

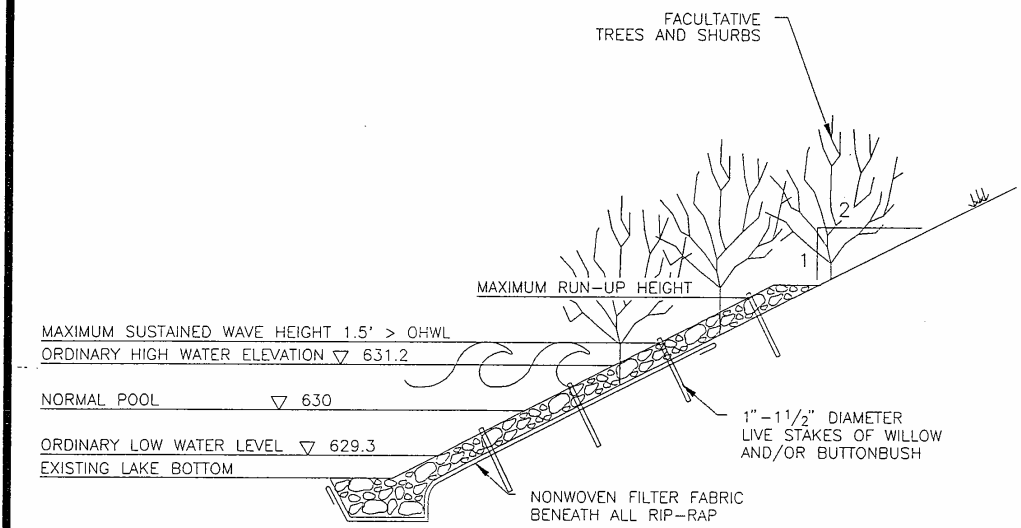


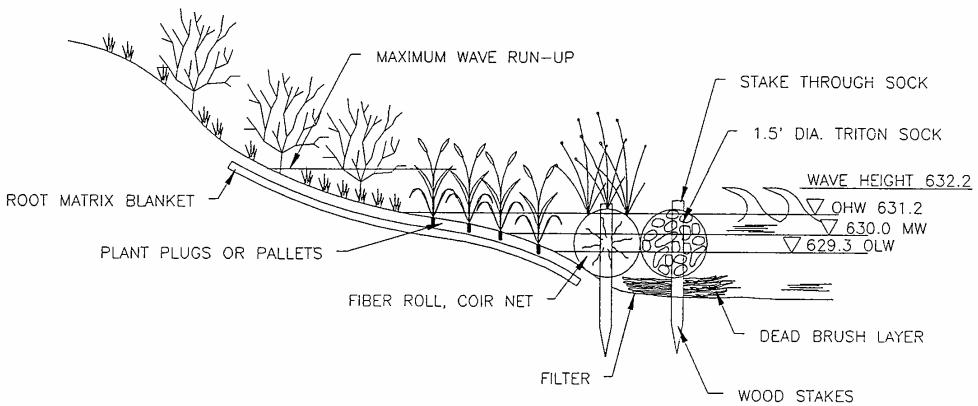
Exhibit 4

NOT TO SCALE

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE / SLOPE 3:1 > 1.5:1
CATEGORY 1

CATEGORY 2 WAVE ENERGY ZONE
MAXIMUM SUSTAINED WAVE HEIGHT < 2'



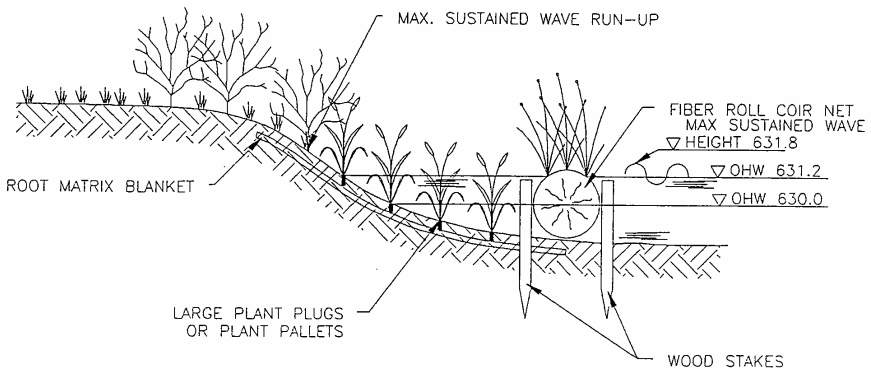
NOT TO SCALE

Exhibit 5

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE / SLOPE 5:1) 3:1
CATEGORY 2

CATEGORY 3 WAVE ENERGY ZONE
MAXIMUM SUSTAINED WAVE HEIGHT (1'
BIOLOGICAL TREATMENT



NOT TO SCALE

Exhibit 6

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE / SLOPE (3:1
CATEGORY 3

CATEGORY 2 AND 3 WAVE ENERGY ZONE
PERMANANT ROOT MATRIX BLANKET TYPICAL INSTALLATION

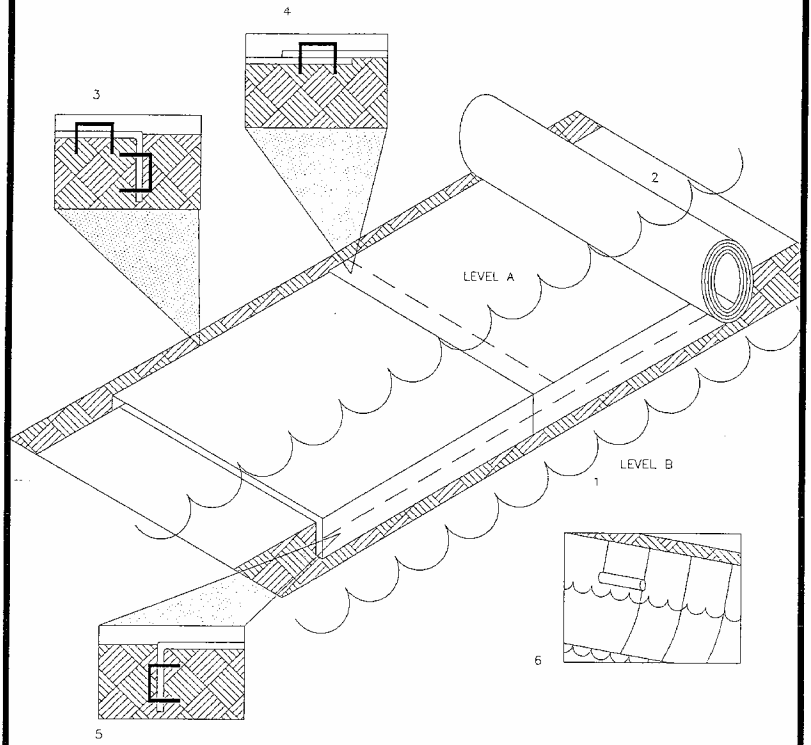


Exhibit 7

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE 3 / SHORELINE SLOPES (3:1
CATEGORY 2 AND 3

CATEGRY 2 AND 3 WAVE ENERGY ZONES
EROSION CONTROL BLANKET PLANT PROTECTION

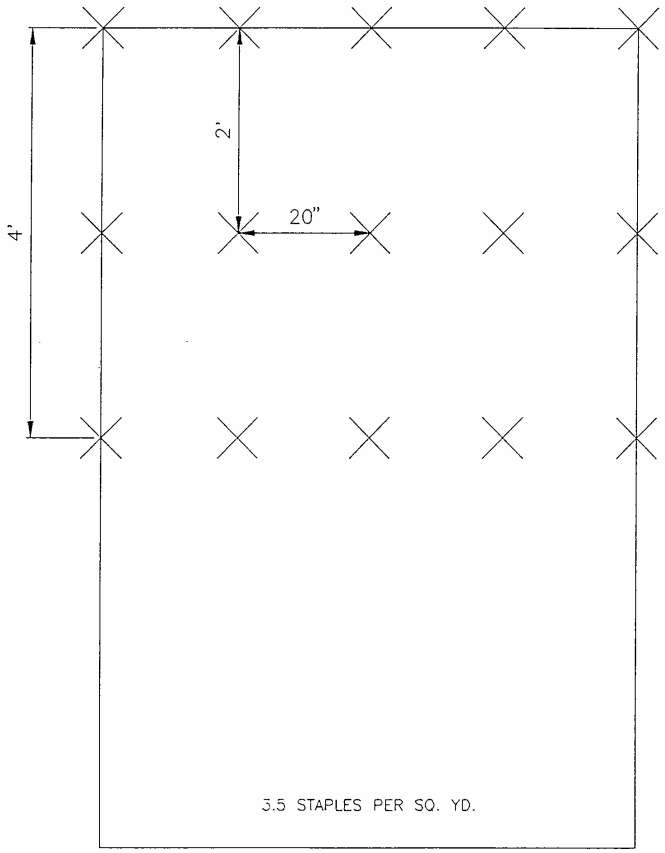


Exhibit 8

COMMONWEALTH BIOMONITORING, INC.

LAKE LEMON BIOTECHNICAL STABILIZATION PROJECT
FEASIBILITY STUDY REPORT
WAVE ENERGY ZONE / SHORELINE
GENERAL STAPLE PATTERN GUIDE + RECOMMENDATIONS

Appendix B

Feasibility Cost Estimation Worksheets for Shoreline Stabilization Alternatives

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: **February 24, 1997** Attachment 1

llatls1.wk4

Location: **All sites with slope 1.5H:1V or less**
Alternative LS-1 - Rip Rap with Geofabric **Category 1 Wave Energy Zone**

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$13.00	$13.00
2	Lake Excavation	0.5					CYS	$6.00	$3.00
3	Riprap, Hand Laid, 10 In. (gabion toe protectic	1					SYS	$55.00	$55.00
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Seeding, Sodding	0					LF	$5.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	1.5	2	CYS	$105.00	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0.33	90	7.5		75	SYS	$3.50	$1.16
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	1.5	300	12.5		417	SYS	$1.90	$2.85
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Conservation Tillage	0					ACRE	$18.00	$0.00
50	Straw Bale Dam (Installed)	0					EA	$30.00	$0.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$78.01**
	Nonconstruction Costs (insp., easements)								**$15.60**
	10% CONTINGENCIES								**$7.80**
	Preliminary Estimated TOTAL								**$101.41**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: **February 24, 1997** Attachment 2

LLALTLS2.wk4

Location: All sites with slope greater than 1.5H:1V
Alternative LS-2 - Gabion Baskets

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$21.87	$21.87
2	Lake Excavation	0					CYS	$6.00	$0.00
3	Riprap, Hand Laid, 10 In. (gabion toe protectic	0.333					SYS	$55.00	$18.32
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Seeding, Sodding	0					LF	$5.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0.3333	12	3	3	4	CYS	$150.00	$50.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0.3333	12	3	1.5	2	CYS	$105.00	$35.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0.33	90	7.5		75	SYS	$3.50	$1.16
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	1	300	12.5		417	SYS	$1.90	$1.90
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Conservation Tillage	0					ACRE	$18.00	$0.00
50	Straw Bale Dam (Installed)	0					EA	$30.00	$0.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$131.23**
	Nonconstruction Costs (insp., easements)								**$26.25**
	10% CONTINGENCIES								**$13.12**
	Preliminary Estimated TOTAL								**$170.60**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: February 24, 1997 Attachment 3

lialtls3.wk4

Location: All sites with slope greater than 1.5H:1V
Alternative LS-3 - Gabion Mattresses Category 3 Wave Energy Zone

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$12.47	$12.47
2	Lake Excavation	0.5					CYS	$6.00	$3.00
3	Riprap, Hand Laid, 10 In. (gabion toe protectic	0.333					SYS	$55.00	$18.32
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Seeding, Sodding	0					LF	$5.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0.333	12	3	1.5	2	CYS	$105.00	$34.97
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0.33	90	7.5		75	SYS	$3.50	$1.16
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	1	300	12.5		417	SYS	$1.90	$1.90
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Conservation Tillage	0					ACRE	$18.00	$0.00
50	Straw Bale Dam (Installed)	0					EA	$30.00	$0.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$74.80**
	Nonconstruction Costs (insp., easements)								**$14.96**
	10% CONTINGENCIES								**$7.48**
	Preliminary Estimated TOTAL								**$97.24**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: February 24, 1997 Attachment 4

llaltls4.wk4

Location: All sites with slope less than 1.5H:1V Category 2 Wave Energy Zone
Alternative LS-4 - Rock Roll & Biologs w/ Plant Palletts

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$11.90	$11.90
2	Lake Excavation	0					CYS	$6.00	$0.00
3	Riprap, Hand Laid, 10 In. (gabion toe protectic	0					SYS	$55.00	$0.00
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Bonterra CS2 Blanket W/ Plants Started	0.33	3	5			LF	$50.00	$16.50
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	1.5	2	CYS	$105.00	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0	90	7.5		75	SYS	$3.50	$0.00
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	0	300	12.5		417	SYS	$1.90	$0.00
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Gabion Sock Rock Roll	1					L.F.	$15.00	$15.00
50	Coir/Coconut Biolog	1					L.F.	$25.00	$25.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$71.40**
	Nonconstruction Costs (insp., easements)								**$14.28**
	10% CONTINGENCIES								**$7.14**
	Preliminary Estimated TOTAL								**$92.82**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: February 24, 1997 Attachment 5

lla1ls5.wk4

Location: All sites with slope less than 1.5H:1V Category 2 Wave Energy Zone
Alternative LS-5 - Rip rap and Geofabric

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$8.69	$8.69
2	Lake Excavation	0.33					CYS	$6.00	$1.98
3	Riprap, Hand Laid, 8 In.	0.5					SYS	$55.00	$27.50
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Bonterra CS2 Blanket W/ Plants Started	0	3	5			LF	$50.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	1.5	2	CYS	$105.00	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0	90	7.5		75	SYS	$3.50	$0.00
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	0.5	300	12.5		417	SYS	$1.90	$0.95
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Gabion Sock Rock Roll	0					L.F.	$15.00	$0.00
50	Removal of Drift and Snags	1					L.F.	$10.00	$10.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$52.12**
	Nonconstruction Costs (insp., easements)								**$10.42**
	10% CONTINGENCIES								**$5.21**
	Preliminary Estimated TOTAL								**$67.75**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: February 24, 1997 Attachment 6

lialtls6.wk4

Location: All sites with slope less than 1.5H:1V Category 2 Wave Energy Zone
Alternative LS-6 - Biologs w/ Plant Palletts

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$8.90	$8.90
2	Lake Excavation	0					CYS	$6.00	$0.00
3	Riprap, Hand Laid, 10 In. (gabion toe protectic	0					SYS	$55.00	$0.00
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Bonterra CS2 Blanket W/ Plants Started	0.33	3	5			LF	$50.00	$16.50
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	1.5	2	CYS	$105.00	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0	90	7.5		75	SYS	$3.50	$0.00
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	0	300	12.5		417	SYS	$1.90	$0.00
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$3.00	$3.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Gabion Sock Rock Roll	0					L.F.	$15.00	$0.00
50	Coir/Coconut Biolog	1					L.F.	$25.00	$25.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$53.40**
	Nonconstruction Costs (insp., easements)								**$10.68**
	10% CONTINGENCIES								**$5.34**
	Preliminary Estimated TOTAL								**$69.42**

SHORELINE STABILIZATION TREATMENT COST FEASIBILITY WORKSHEET

PRELIMINARY CONSTRUCTION COST ESTIMATES PER LINEAR FOOT OF SHORELINE
COMMONWEALTH BIOMONITORING, INC.

UPDATED: **February 24, 1997** Attachment 7

lialts7.wk4

Location: **All sites with slope less than 2H:1V** **Category 3 Wave Energy Zone**
Alternative LS-7 - Biologs With Plants

NO.	ITEM	QTY	LENGTH	WIDTH	HEIGHT	CAP	UNITS	INST. UNIT $	TOTALS
1	Mobilization, Bond, etc. (20%)	1					LS	$7.00	$7.00
2	Lake Excavation	0					CYS	$6.00	$0.00
3	Riprap, Hand Laid, 10 in. (gabion toe protectic	0					SYS	$55.00	$0.00
4	Shot Rock (250Lb)	0					CYS	$120.00	$0.00
5	0.375" Steel Sheet Piling	0					SF	$25.00	$0.00
6	Bonterra CS2 Blanket W/ Plants Started	0	3	5			LF	$50.00	$0.00
7	Enkamat ER7010-5 (15.58'w 500'l 866 syd)	0	500	15.58		866	SYS	$8.50	$0.00
8	Enkamat ER7020-5 (15.58'w 277'l 480 syd)	0	277	15.58		480	SYS	$11.65	$0.00
9	Enkaflat ER7210-5 (15.58'w 394'l 682 syd)	0	394	15.58		682	SYS	$8.50	$0.00
10	Enkaflat ER7220-5 (15.58'w 197'l 341 syd)	0	197	15.58		341	SYS	$12.65	$0.00
11	Galv. Gabions ERGG12x3x3 (4 cys)	0	12	3	3	4	CYS	$150.00	$0.00
12	Galv. Gabions ERGG12x3x1.5 (2 cys)	0	12	3	1.5	2	CYS	$105.00	$0.00
13	Galv. Gabions ERGG12x3x1 (1.33 cys)	0	12	3	1	1.33	CYS	$85.00	$0.00
14	Bonterra E.C. Blankets S1 (75 sys)	0	90	7.5		75	SYS	$1.30	$0.00
15	Bonterra E.C. Blankets S2 (75 sys)	0	90	7.5		75	SYS	$2.00	$0.00
16	Bonterra E.C. Blankets CS2 (75 sys)	0	90	7.5		75	SYS	$3.00	$0.00
17	Bonterra E.C. Blankets C2 (75 sys)	0	90	7.5		75	SYS	$3.50	$0.00
18	Geotextile FRWTNO312.5 (12.5X360 500 sys	0	360	12.5		500	SYS	$1.00	$0.00
19	Geotextile FRWTNO412.0 (12.5x360 500 sys	0	360	12.5		500	SYS	$1.25	$0.00
20	Geotextile FRWTNO712.5 (12.5x300 417 sys	0	300	12.5		417	SYS	$1.90	$0.00
21	PVC Gabions ERPG12x3x3 (4 sys)	0	12	3	3	4	SYS	$150.00	$0.00
22	PVC Gabions ERPG12x3x1.5 (2 sys)	0	12	3	1.5	2	SYS	$120.00	$0.00
23	PVC Gabions ERPG12x3x1 (1.33 sys)	0	12	3	1	1.33	SYS	$95.00	$0.00
24	Terracell ERTC4 (4" 8000-31840 sf)	0					SF	$2.00	$0.00
25	Terracell ERTC8 (8" 4000-15840 sf)	0					SF	$3.00	$0.00
26	Grassed Waterways	0					LF	$4.25	$0.00
27	Vegetated Buffer Strips (Grass, Legume)	0					ACRE	$120.00	$0.00
28	Vegetated Buffer Strips (Wooded)	0					ACRE	$350.00	$0.00
29	24" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.50	$0.00
30	36" Silt Fence, Posts every 8' (100' Roll)	0					LF	$0.65	$0.00
31	Fencing (Farm Field)	0					LF	$12.00	$0.00
32	Filterstrips 40' Width (Grass, Legume)	0					ACRE	$130.00	$0.00
33	Filterstrips 40' Width (Wooded)	0					ACRE	$350.00	$0.00
34	Ponds/Wetlands (Constructed)	0					CYS	$5.00	$0.00
35	WASCOBS (Water & Sed. Control Basins)	0					EA	$1,800.00	$0.00
36	Conservation Esmnts (Marginal Farmland)	0					ACRE	$650.00	$0.00
37	Conservation Esmnts (Average Farmland)	0					ACRE	$900.00	$0.00
38	Conservation Esmnts (Prime Farmland)	0					ACRE	$1,400.00	$0.00
39	Sed. Excavation to Create Berms	0					CYS	$7.50	$0.00
40	Sediment Hauling (1 Mile Round Trip)	0					CYS	$2.50	$0.00
41	Sediment Hauling (2 Mile Round Trip)	0					CYS	$3.00	$0.00
42	Sediment Hauling (4 Mile Round Trip)	0					CYS	$3.80	$0.00
43	Sediment Hauling (10 Mile Round Trip)	0					CYS	$7.00	$0.00
44	Filter Fabric	0					SYS	$3.25	$0.00
45	Grade Stabilization Structure	0					EA	$4,500.00	$0.00
46	Waste Management System (Livestock)	0					EA	$25,000.00	$0.00
47	Streambank & Shoreline Planting	1					LF	$5.00	$5.00
48	Nutrient Management	0					ACRE	$3.00	$0.00
49	Gabion Sock Rock Roll	0					L.F.	$15.00	$0.00
50	Coir/Coconut Biolog	1					L.F.	$30.00	$30.00
51	Critical Area Planting Shaping	0					ACRE	$500.00	$0.00
52	Mulching (Straw)/(Anchored by Treading)	0					ACRE	$600.00	$0.00
	Preliminary Estimated SUBTOTAL								**$42.00**
	Nonconstruction Costs (insp., easements)								**$8.40**
	10% CONTINGENCIES								**$4.20**
	Preliminary Estimated TOTAL								**$54.60**